This document is downloaded from the
VTT's Research Information Portal
https://cris.vtt.fi

VTT Technical Research Centre of Finland

Giving Birth to the First Decommissioning Licence in Finland

Airila, Markus

Published: 11/10/2020

Document Version
Publisher's final version

License
Unspecified

Link to publication

Please cite the original version:
Airila, M. (2020). *Giving Birth to the First Decommissioning Licence in Finland: Case FiR 1 TRIGA reactor at VTT*. Paper presented at RRFM2020 - European Research Reactor Conference.

VTT
http://www.vtt.fi
P.O. box 1000FI-02044 VTT
Finland

By using VTT's Research Information Portal you are bound by the following Terms & Conditions.

I have read and I understand the following statement:

This document is protected by copyright and other intellectual property rights, and duplication or sale of all or part of any of this document is not permitted, except duplication for research use or educational purposes in electronic or print form. You must obtain permission for any other use. Electronic or print copies may not be offered for sale.

Download date: 04. May. 2023

GIVING BIRTH TO THE FIRST DECOMMISSIONING LICENCE IN FINLAND. CASE FiR 1 TRIGA REACTOR AT VTT

M.I. AIRILA
Nuclear Energy, VTT Technical Research Centre of Finland Ltd.
Kivimiehentie 3, 02150 Espoo – Finland

ABSTRACT

In 2017, VTT Technical Research Centre of Finland applied for a decommissioning licence for the FiR 1 research reactor, which was operated in Espoo in 1963–2015. The Government of Finland will soon decide on granting the licence, being first-of-a kind in Finland. We summarize the main steps towards fulfilling the prerequisites for the licence. These include safety, personnel and financial capacity of the applicant, but in particular, that *the methods available to the applicant for the decommissioning of the nuclear facility as well as other nuclear waste management are adequate and appropriate* [1]. In spring 2020 VTT reported that a comprehensive contract on decommissioning services had been signed covering dismantling of FiR 1 and all necessary nuclear waste management services, including interim storage location for FiR 1 fuel from 2022 onwards. With this solution confirmed, all other decommissioning activities can be scheduled accordingly.

1. From shut-down decision (2012) to regulator's safety assessment (2019)

Eight years have passed since VTT's decision to shut down the FiR 1 reactor. Following the closure decision, an environmental impact assessment (EIA) was carried out for the decommissioning in 2013–15, after which VTT launched the actual decommissioning project, set the reactor to permanent shutdown state in June 2015 and made the core permanently subcritical in December 2015, terminating the training, research and isotope production carried out at FiR 1. Finnish universities with nuclear curricula have continued their hands-on reactor exercises on foreign research reactors. As far as cancer treatments previously given on FiR 1 are concerned, a new accelerator-based BNCT station will soon be completed in Helsinki University Hospital [2] to continue BNCT operations.

Fig 1. *FiR 1 operator in the control room on the last operating day 30 June 2015. The same year, the core was made permanently subcritical by removing a number of fuel elements.*

The first concrete goal of the decommissioning project was to prepare the decommissioning licence application. The application we submitted to the Government in June 2017 is accompanied by a relatively extensive background material (see Sections 34 and 36 of the Finnish Nuclear Energy Decree [3]), which the Radiation and Nuclear Safety Authority (STUK)

has inspected from a technical point of view. The application and its actual annexes are available on the website [4] of the Ministry of Economic Affairs and Employment (MEAE). A completely novel part of the documentation is the decommissioning plan, for which two background studies were particularly instrumental: (i) the detailed dismantling plan (see [5]) prepared by Babcock Noell GmbH (BNG, part of the German Bilfinger Group) and (ii) the detailed computational determination of the reactor structures by VTT. In addition, numerous separate safety analyses provided input to the decommissioning plan. Besides the decommissioning plan, all reactor plant documentation, e.g. the quality assurance, organization and safety analysis report have been updated to meet the new requirements arising in the decommissioning phase. STUK issued their statement on the licence application and the decommissioning safety assessment in April 2019 [6,7].

2. Prerequisites for granting a licence: 2 x 50% < 100%

The three-plus-year review time for a licence application may sound long to many, given the decommissioning of a small and safe nuclear facility that will yield relatively small amounts of nuclear waste. However, the reason is not the slowness of official processing. According to the Nuclear Energy Act, the granting of a licence requires (among several other requirements) that *the methods available to the applicant for the decommissioning of the nuclear facility as well as other nuclear waste management shall be adequate and appropriate* [1]. In practice, VTT's application has not been fully ready for processing until spring 2020, when we supplemented the information on the status of nuclear waste management agreements related to the project with a letter to MEAE.

The *adequate and appropriate methods*, referred to above, must be organized in essentially three areas: (i) Reactor dismantling and all related on-site arrangements; (ii) Spent fuel management; (iii) Disposal of low and intermediate level dismantling and operational waste resulting from operation and decommissioning. VTT's starting point has been that we procure external services for all these phases, as industrial decommissioning and the practical implementation of nuclear waste management are not research institute's core business.

At the time of submitting the licence application, the nuclear waste management solutions presented by VTT had excessive uncertainties, effectively preventing a smooth initiation and execution of the project. Taking a close analogy from probability theory, if you for example perform two independent experiments with 50 % likelihood each, a finite probability remains (in this example case 25 %) for the result that neither of the two experiments will yield a positive result. With regard to low and intermediate level nuclear waste management solutions for VTT, the uncertainties were related to the fact that only preliminary agreements were in place, without all the essential terms being agreed on. With regard to spent fuel, the particular source of uncertainty was the fact that fuel returns from foreign research reactors to the United States have stalled and the time window for the return program was about to close. Thus, the conditions for granting the decommissioning licence were not met before VTT signed the comprehensive and binding decommissioning service contract described below.

3. Shopping list: Nuclear waste management

From the services required by VTT, the decommissioning work at the reactor site would be the easiest to acquire as a separate procurement, as international experience in decommissioning nuclear power plants and other nuclear facilities is well available. There are many companies and consortia in the field, and we have a strong perception that a project in Finland would raise quite strong interest elsewhere in Europe. Previously, when procuring the dismantling planning in 2016, we received numerous good offers and finally a high-quality plan from Babcock Noell GmbH almost exactly on schedule and within budget. That said, the buyer's position seemed to be good. References obtained in Finland are relatively highly valued abroad, as the Finnish regulation of the nuclear energy sector is known to be thorough. Therefore, a successfully implemented project is a proof of quality for the service provider. In addition, dismantling

planning of a research reactor, but also the decommissioning itself can be seen as relatively low-risk projects due to their scale, and therefore attractive.

However, we ended up procuring the services as a larger entity – that is, we picked up in the same basket both the dismantling work and the nuclear waste management services we needed. This was not an impulse purchase, but was because the supply of nuclear waste management services is geographically much more limited than the supply of decommissioning services. Generally, export of nuclear waste permanently from Finland is prohibited (while there is an exemption in the Nuclear Energy Act, which allows returning spent nuclear fuel from the research reactor to its country of origin, the United States). Thus, we mapped the possibilities of Finnish nuclear power companies to offer nuclear waste reception as a service. Bilateral market consultations with both power companies matured VTT's decision to formulate the procurement into a package containing both the dismantling work and the nuclear waste management services. VTT carried out the procurement using the negotiation procedure in accordance with the Act on Public Procurements and Concession Contracts [8]. The procedure allows both the buyer and the seller to obtain significant additional information before the final call for tenders and final tenders, which is essential when the subject of the contract is complex, subject to strict legislation and challenging to scope, for example in terms of responsibilities.

Looking back, VTT succeeded extremely well in the formulation of the procurement package, as we entered into an excellent agreement with Fortum in spring 2020. The agreement eliminates most of the uncertainties that have long overshadowed the FiR 1 decommissioning project. The partnership with Fortum encompasses all the above areas: it fully covers both the decommissioning work and the reception of decommissioning and decommissioning waste, as well as, if necessary, the interim storage of spent fuel, so that decommissioning can begin as planned. Under the same agreement, the management of the radioactive decommissioning waste of VTT’s OK3 laboratory, also presently under decommissioning, has also been arranged in its entirety.

VTT has now been able to report to MEAE that the decommissioning service agreement meets VTT's nuclear waste management needs, except the transfer of responsibility for the spent nuclear fuel (e.g. for final disposal). As a licensee of a nuclear power plant, Fortum has sufficient expertise and an operating system to meet its contractual obligations, so VTT considers that the methods currently available for decommissioning the reactor, including other nuclear waste management, have improved significantly and are adequate and appropriate.

4. Spent fuel as the pain point

Throughout its operating history, FiR 1 has produced 103 spent TRIGA fuel elements, or about 300 kg of spent nuclear fuel (slightly over 20 kg_U). VTT's primary option for spent fuel management is to return it to the United States, which option has also been unanimously supported by all stakeholders giving their statements during the EIA and licensing process. However, fuel returns from foreign research reactors to the Idaho National Laboratory (INL) have been halted since the fall of 2014. For this reason, the US Department of Energy (DOE) has extended the Foreign Research Reactor Spent Nuclear Fuel Acceptance Program for selected reactors, including FiR 1, which would otherwise have concluded in May 2019. DOE has announced that VTT can return spent fuel until May 2029.

VTT has continued the preparation of a fuel acceptance agreement and provided MEAE with up-to-date information on the situation to support the correspondence between Finnish ministries and the US. The contents of the return contract and the transport contract have been negotiated in such a way that the transport arrangements are as ready as possible. VTT has commissioned the transport plans required for the transport licence and prepared licence applications. Upon VTT’s application, STUK has in February 2020 validated the US NRC’s certificate for the packaging design of the NAC-LWT cask so that the cask can be used for

transports in and from Finland. NAC International as the cask operator recently completed the manufacturing and quality assurance of the cask internals for FiR 1 fuel (fuel element baskets and sealed cans for failed fuel), reducing the lead time for transport preparation.

VTT's domestic spent fuel management option is based on an agreement in principle between VTT and Posiva Ltd. The agreement was originally valid for five years from the final shutdown of the reactor, i.e. until the end of June 2020. According to the agreement, VTT shall notify Posiva of the possible need to use Posiva's spent fuel disposal facilities during the term of the agreement. In December 2019, VTT and Posiva signed a 10-year extension to the agreement in principle until the end of June 2030. The agreement in principle thus remains as the basis for the domestic option beyond a sufficient interim storage period until it is possible to return spent nuclear fuel to the United States under the new repatriation program. Licensing issues related to a possible final disposal in Finland are not currently topical, but VTT and Posiva will resume the negotiations in good time before 2030 if the domestic option turns necessary.

As the completion and timing of the return to the United States have not been confirmed, VTT is preparing in parallel for an alternative solution alongside transport preparation, i.e. to transfer the FiR 1 spent fuel for interim storage to Loviisa NPP under the contract described above. Fortum, the licensee of Loviisa NPP, will be responsible for the schedule and implementation of the licensing work related to this option.

5. Our learnings so far

With Finland's first decommissioning, a test effort has been made not only of VTT's ability to take care of its obligations, but also of legislation and regulator's requirements and guidelines. We have held regular follow-up meetings with MEAE and STUK and, for example, discussed practical interpretations of the guidelines when it has not been feasible to apply them literally in the particular situation of Finland and VTT. Decommissioning is topical in Finnish legislation in the sense that it constitutes a substantial part of the amendment to the Nuclear Energy Act, which entered into force in 2018. STUK, for its part, has taken into account the feedback received from VTT in the latest update of STUK's YVL Guides.

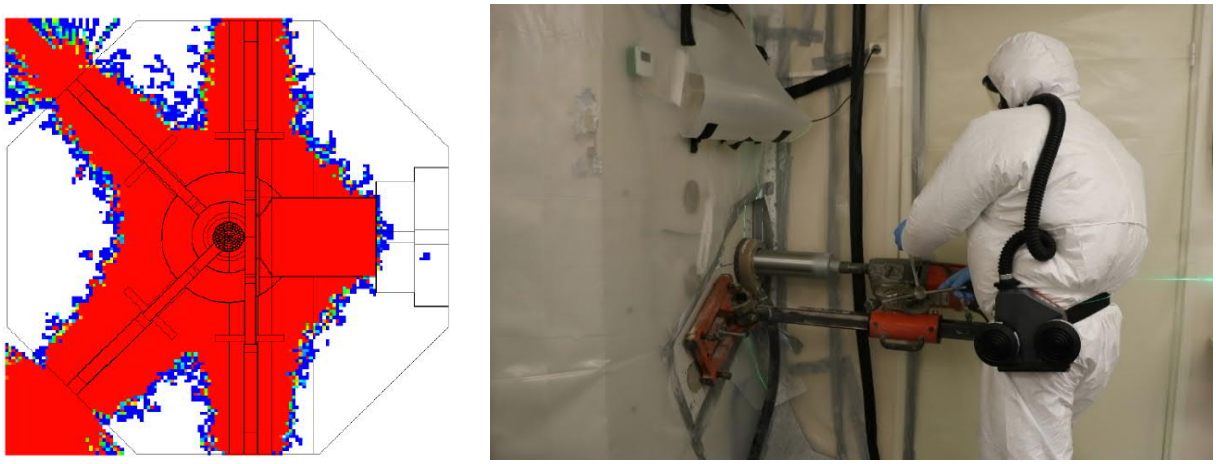

Fig 2. *An estimate based on 3D inventory calculation of the activated part of the concrete in the reactor's biological shield, from which the resulting decommissioning waste is treated as nuclear waste (red). The rest of the concrete can be free released and recycled as conventional construction waste. To validate the calculation, concrete was sampled in December 2018.*

VTT utilized in-house expertise to determine a detailed computational radionuclide inventory at an early stage of decommissioning planning. This inventory has proved to be an extremely valuable source of information in almost all areas of the project. The calculation has been made separately for spent fuel and reactor structures, taking into account the entire operating history

of the reactor with its various configurations, detailed 3D geometry and all material composition data as accurately as possible. Where necessary, additional material composition measurements were carried out to complement the input data. The results have applications in dismantling planning (methods and occupational safety), waste planning (waste quantities, packaging and storage facilities) as well as project scheduling and budgeting (workloads and equipment). Validation of computational inventories through sampling and measurements proceeds as various reactor structures are accessed at different stages of decommissioning. A dissertation on the subject has just been completed [9].

In terms of organization, VTT has succeeded in maintaining a strong facility knowledge – essentially the entire operating staff is still available to the project, in addition to which the project organization has been strengthened above all by hiring experienced experts for the decommissioning planning and implementation phase. We have also taken benefit from expertise outside Finland by hiring foreign companies for planning and, of course, by networking in international conferences and seminars.

The transition from reactor operation to decommissioning is a challenge for which no amount of preparation is enough. While the maintenance of the facility continues in the permanent shutdown state as before, the team's attitude must adapt for the almost daily changing situation during the decommissioning phase, the increase of external labour and the dramatic increase in nuclear waste compared to in-service waste management. We have recognized that the change is challenging our established thinking and the safety culture based on it, and have sought to evaluate and develop the prevailing safety culture with a view to decommissioning.

6. About schedule and cost

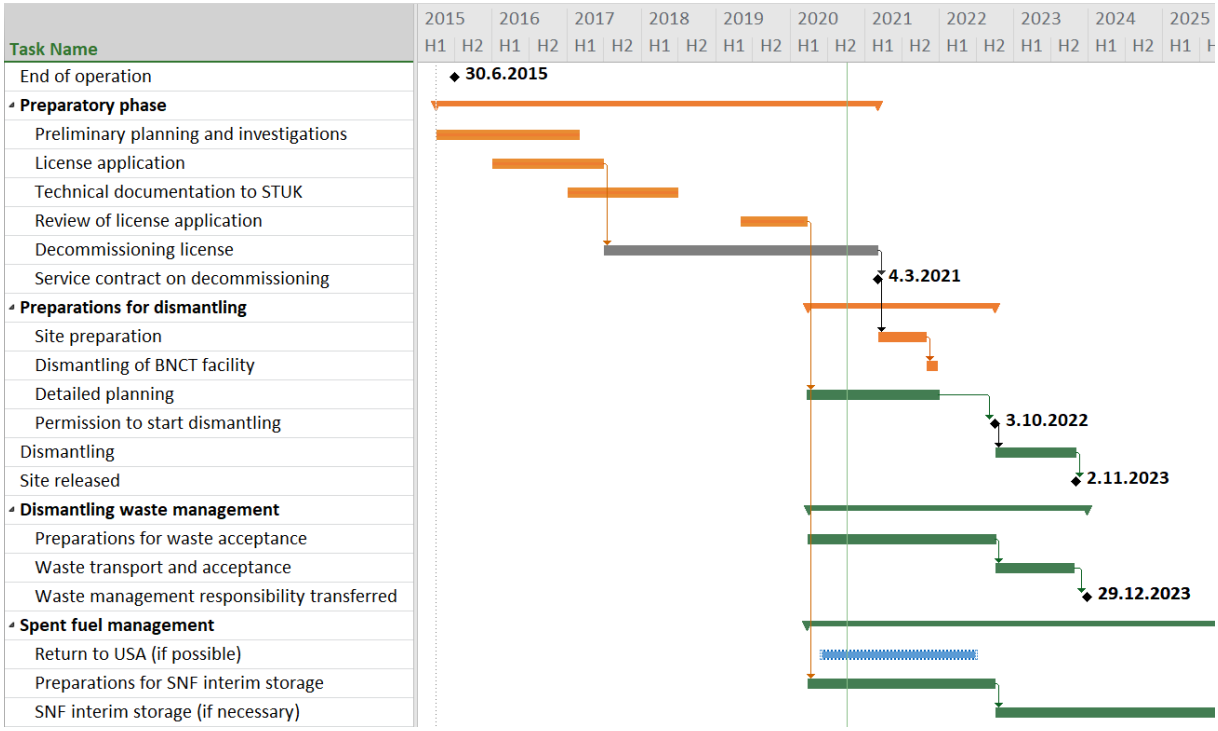

Fig. 3. *Estimated schedule for decommissioning and nuclear waste management of FiR 1. The steps marked in green are mainly carried out under VTT's and Fortum's contract. The blue bar indicates the time window for direct return of the spent fuel to the US. For the time being, VTT continues the preparations for interim storage of the spent fuel.*

Despite the preparations described above, we initially underestimated the amount of work and time required to prepare the extensive licensing materials and to enter into binding nuclear waste management agreements. The confirmation of nuclear waste management solutions at

too late a stage – both in the United States and domestically – has been a multi-year burden on the project, with many design boundary conditions remaining volatile for a long time. According to the current plan, the transfer of fuel to the interim storage and the main dismantling phase can be initiated immediately after Fortum obtains the licence to receive VTT's waste in 2022–23, and subsequently the reactor would be decommissioned by the end of 2023. The possible return of spent fuel to the United States will no longer have a critical accelerating effect on the decommissioning implementation schedule, as dismantling is planned to start no earlier than when decommissioning waste can be directly transported from the reactor site. Licensing the receipt of decommissioning waste requires practically the same amount of time as does the preparation of the interim storage for spent fuel.

VTT has annually updated the decommissioning cost estimate for the purpose of determining VTT's financial provision obligation under the Nuclear Energy Act. Presently, VTT's fund share in the State Nuclear Waste Management Fund (VYR) is slightly less than EUR 23 million, which corresponds to the costs estimated to be realized after the end of 2019. Adding to the amount the previously incurred costs, the total cost estimate of the project is approximately EUR 31 million. In 2018, the State of Finland has granted a special appropriation for decommissioning, which has been used to increase VTT's VYR share in line with the cost estimate.

7. Meanwhile – the law has changed

Finally, to be very precise, we mention as a curiosity that the licence, expected to be granted to VTT soon, is an *operating licence* in accordance with Section 20 of the Nuclear Energy Act, the purpose of which, however, is to decommission the plant. This specialty is due to the fact that the *decommissioning licence* (Section 20 a) was introduced in the Nuclear Energy Act in 2018 only after the submission of VTT's licence application, and the amendment will not be applied retroactively. In other words, Finland's first decommissioning licence mentioned in the title of this paper is in fact still waiting for its applicant on the Ministry's shelf at the top of the neighbouring stack.

The FiR 1 research reactor was a key nuclear energy training and research facility for almost two generations, and now it serves as a pilot facility also in the decommissioning phase. The licensing phase of the project has tested both VTT's capability to fulfil the requirements and liabilities, but also the Finnish nuclear legislation, regulations and authorities' guidelines. Exchange of experiences between VTT and authorities has led to improvements in the new Nuclear Energy Act and the YVL guides issued by the Radiation and Nuclear Safety Authority STUK. The lessons learned during the decommissioning of FiR 1 can be applied to the preparations for the decommissioning of nuclear power reactors.

Acknowledgements

At this point, I have a reason to write a long paragraph of acknowledgements. The work reported herein is a team effort, which I have only written up on behalf of my present and former VTT colleagues Iiro Auterinen, Tommi Kekki, Petri Kotiluoto, Maarit Lahti, Anumaija Leskinen, Nora Pyhälammi, Esko Ruokola, Antti Räty, Olli Vilkamo, Merja Airola, Kim Calonius, Asta Forsell, Juha Forsström, Tuukka Hahl, Jori Helin, Jouni Hokkinen, Silja Häkkinen, Mikko Ilvonen, Aku Itälä, Joonas Järvinen, Anne Kemppainen, Perttu Kivelä, Virpi Kupiainen, Tiina Lavonen, Jari Likonen, Emmi Myllykylä, Jukka Rossi, Jarmo Siivinen, Vesa Suolanen, Merja Tanhua-Tyrkkö, Susanna Teppola, Pekka Viitanen, Christina Vähävaara, Marja Ylönen, and many others including all our supervisors at VTT. Our long partnership with Anni Jaarinen, Matti Kaisanlahti, Petra Lundström, Ville Oinonen and their colleagues at Fortum, as well as with Tapio Lahtinen and Uttrang Thor-Touch from PTC Services during 2019–20 greatly advanced the licensing, vital for VTT's project. While the Finnish authorities MEAE and STUK are demanding, we at VTT want to acknowledge their solution-oriented attitude and willingness to exchange constructive feedback. Moreover, we at VTT are grateful for the various ways of support that our project has received from other domestic and international stakeholders.

References

[1] *Finnish Nuclear Energy Act* https://www.finlex.fi/fi/laki/kaannokset/1987/en19870990.pdf

[2] https://www.hus.fi/en/about-hus/Hospital_areas/Comprehensive-Cancer-Center/Pages/BNCT-Project.aspx

[3] *Finnish Nuclear Energy Decree* https://www.finlex.fi/fi/laki/kaannokset/1988/en19880161_20090732.pdf

[4] *Decommissioning of VTT's FiR 1 research reactor. Licence application* https://tem.fi/documents/1410877/2429226/Decommissioning+of+VTTs+FiR+1+research+reactor+licence+application.pdf

[5] H. Pohl, C. Ruff and H. Starke, *An Inside View in Planning and Execution of Decommissioning Projects of Research Reactors*, RRFM2017 Conference, Rotterdam, Netherlands, 14–18 May 2017

[6] *Säteilyturvakeskuksen lausunto FiR 1 -tutkimusreaktorin käytöstäpoistoa koskevasta lupahakemuksesta* (in Finnish) https://www.stuk.fi/documents/12547/103416/Lausunto_2_4_2019_2_F48401_2017_STUKin_lausunto_FiR_1_-tutkimusreaktorin_kaytostapoistoa_koskevasta_lupahakemuksesta.pdf

[7] *FiR 1 -tutkimusreaktorin käytöstäpoistoa koskeva turvallisuusarvio* (in Finnish) https://www.stuk.fi/documents/12547/103416/Lausunto_2_4_2019_2_F48401_2017_Liite_1_Tutkimusreaktorin_FiR_1_kaytostapoistoa_koskeva_turvallisuusarvio.pdf

[8] *Finnish Act on Public Procurement and Concession Contracts* https://www.finlex.fi/fi/laki/kaannokset/2016/en20161397.pdf

[9] A. Räty, *Activity Characterization Studies in FiR 1 TRIGA Research Reactor Decommissioning Project*. Doctoral dissertation, University of Helsinki, 2020 http://urn.fi/URN:ISBN:978-951-51-6051-5